

INFLATABLE ANTENNAS FOR MICROWAVE POWER TRANSMISSION

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L'GARDE SPACE INFLATABLES

Various ABRES (IEO, DDT, AMT, AREP, TREP) (1971 through 1978)	Sounding rocket and ICBM flights
Space Defense ITV (SD) Have Busk I (RPL)	Study Study
Reflectors Antenna (NASA) Antenna (Martin) VOA (TRW/State) Solar Concentrator (RPL)	Study Study Study Ground test
SDI - related Radiator (AFWAL SDIO) NP. Beam (SAIC LMSC) SRMP (BMO/USASDC) STEP SD (in evaluation)	Ground test Flight test Flight test Flight test

INFLATABLE SPACE STRUCTURES

NASA - antennas

USAF-BMO - decoys

USAF-SD - ITV

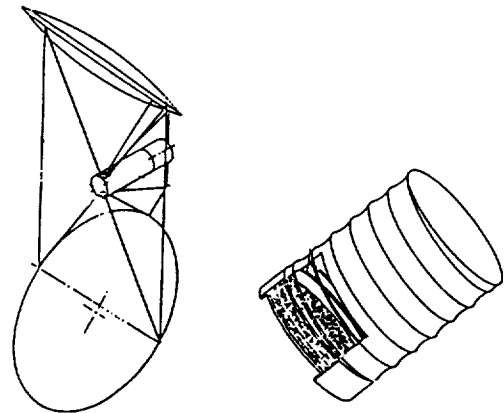
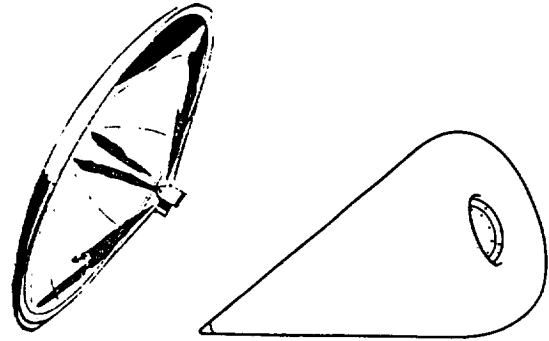
AFRPL - Solar collector

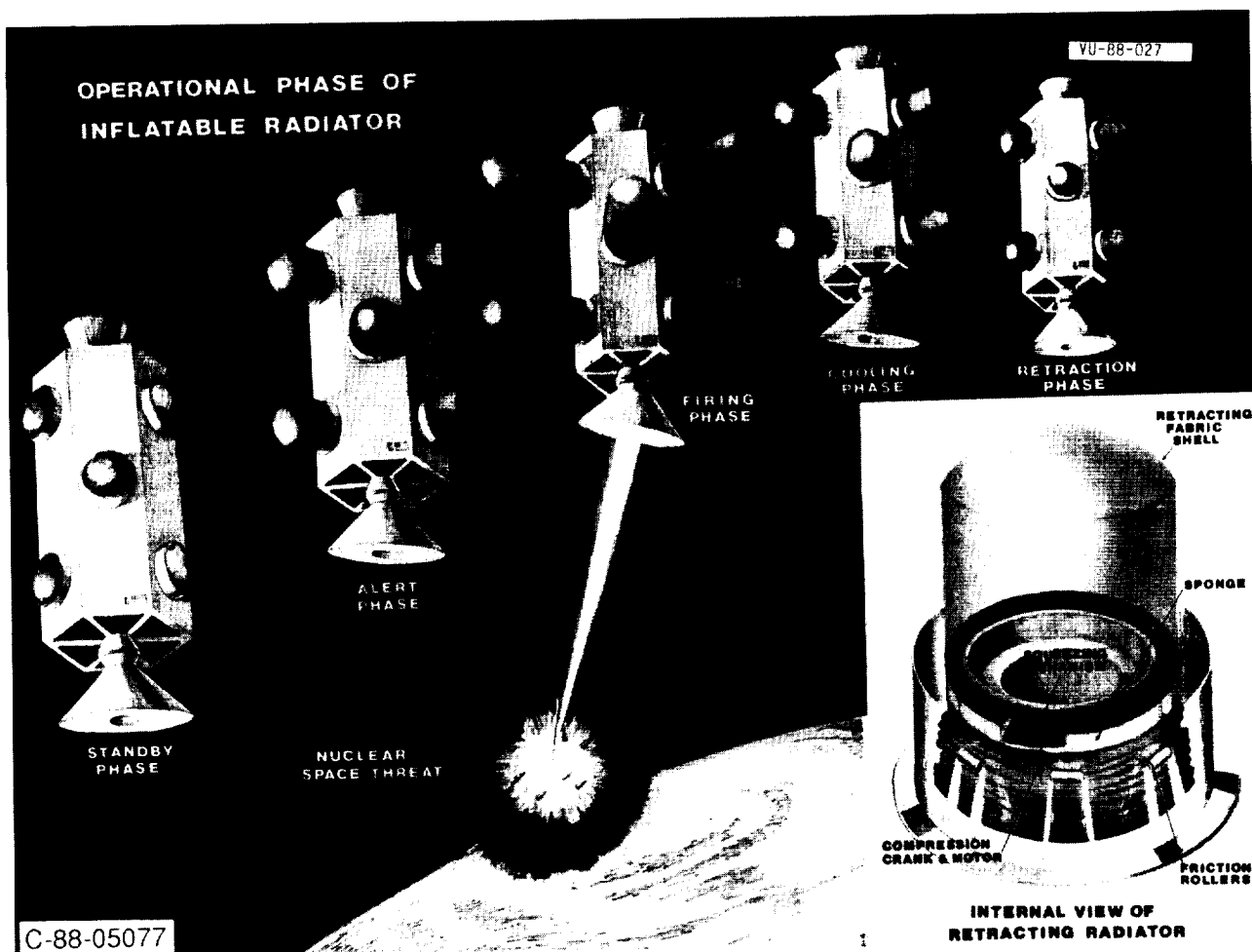
AFWAL - radiator

SDIO - radiator

USASDC - decoys

Aerospace Companies: (TRW, Martin,
MDAC, Avco, MIT/LL)

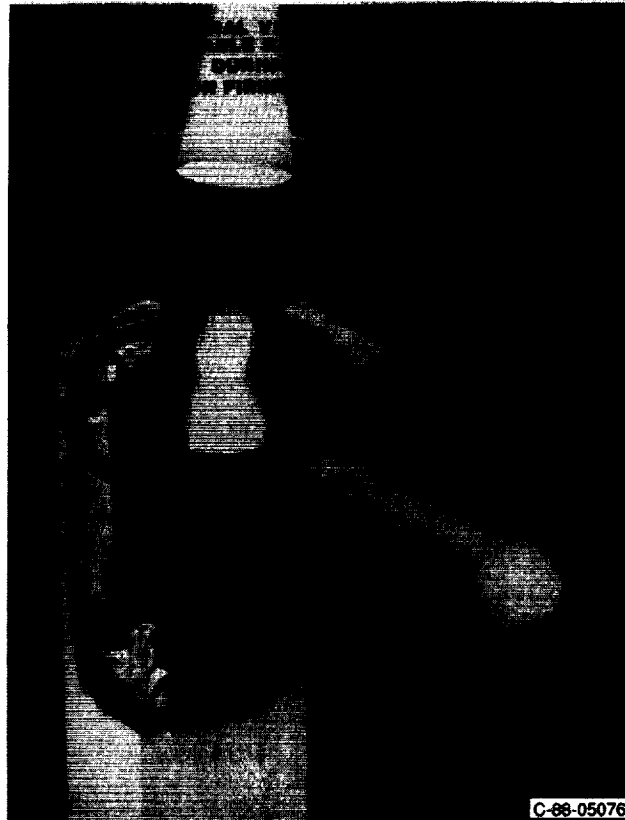




OPERATIONAL PHASE OF THE INFLATABLE RADIATOR

This picture shows the operations phases of a weapon system using the High Power Inflatable Radiator Systems (HIRS) and the insert shows the design of an inflatable radiator. The operation of HIRS is described as follows: In its normal standby phase the inflatable radiator is housed inside the space weapon system to enhance its survivability and to keep it at a temperature where the liquid water, used in the system, will not freeze. In the alert phase a small amount of water vapor is used to inflate the radiator fabric bag at low pressure. This is done to keep the bag from bursting as a result of the high water vapor pressure impulse developed in a short time during the firing phase. In the firing phase the radiator is designed to operate for 2 minutes continuously. This is based on a polar orbit of 100 minutes where the radiator will be ready for use 4 minutes of this time. The radiator system will be capable of dissipation between 10 and 100 megawatts (mw) levels of waste heat. During the cooling phase the waste heat will be dissipated in space by condensation on the inside of the fabric bag. As the vapor pressure subsides a sensor will actuate the retraction mechanism to bring in the bag. A 5.6 psi pressure will be maintained in the bag during retraction in order to keep the bag stable, to facilitate folding the fabric radiator, and to prevent freezing of water on the cold side of the bag. After all the heat is dissipated the bag will be folded and stored in the temperature controlled environment of the spacecraft. The water vapor will have condensed, and the liquid will have been collected and returned to a reservoir to use again.

In the insert the inflatable radiator is shown partially retracted. The fabric bag will be made of a material which has low water permeability, a fabric and seam strength of 500 lbs/linear in., high emissivity and a low contamination level factor for the space surrounding the weapon system. Water recovery is done by using a sponge to gather the water which has condensed on the sides of the radiator, and then squeezing the sponge into a recovery system which transmits it to a reservoir to be used again. The friction rollers and motor are used to roll in the fabric radiator and then fold it into the spacecraft.



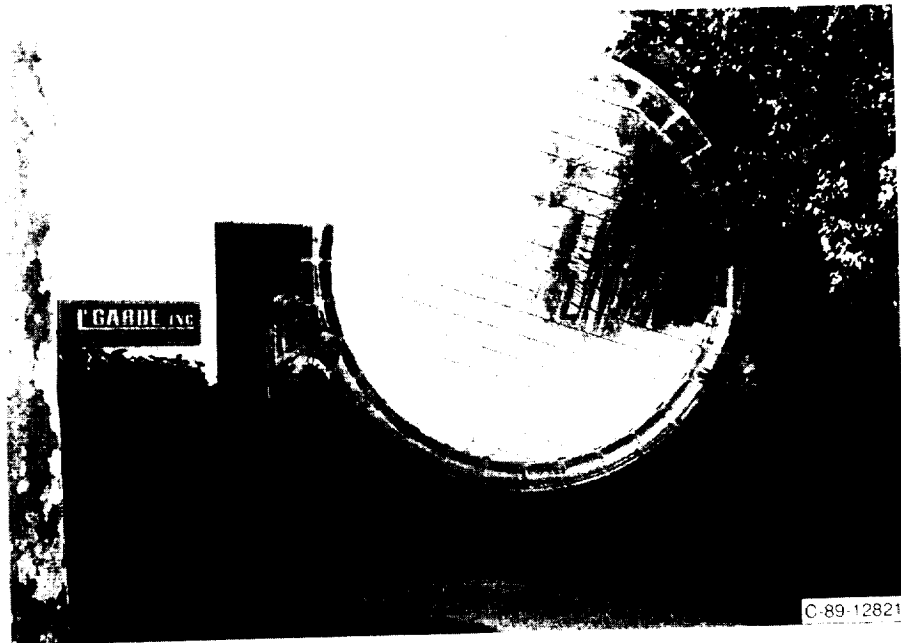
INTERNAL VIEW OF THE INFLATABLE RADIATOR DURING WEAPON FIRING PHASE

This picture shows the internal view of the inflatable radiator during the space weapon's firing phase. The waste heat from the weapon is absorbed by the boiler tubes surrounding it. The water is turned into water vapor at 75°C and then is forced through a vapor/liquid separator where the vapor is directed toward the inflatable fabric radiator and the water is returned to the reservoir. The vapor pressurizes the radiator, which has previously been inflated at low pressure to avoid destroying it during the actual firing phase. The vapor condenses on the radiator wall where it is then sponged up, recovered and returned to the reservoir to be used again. The operational characteristics for the inflatable radiator are as follows.

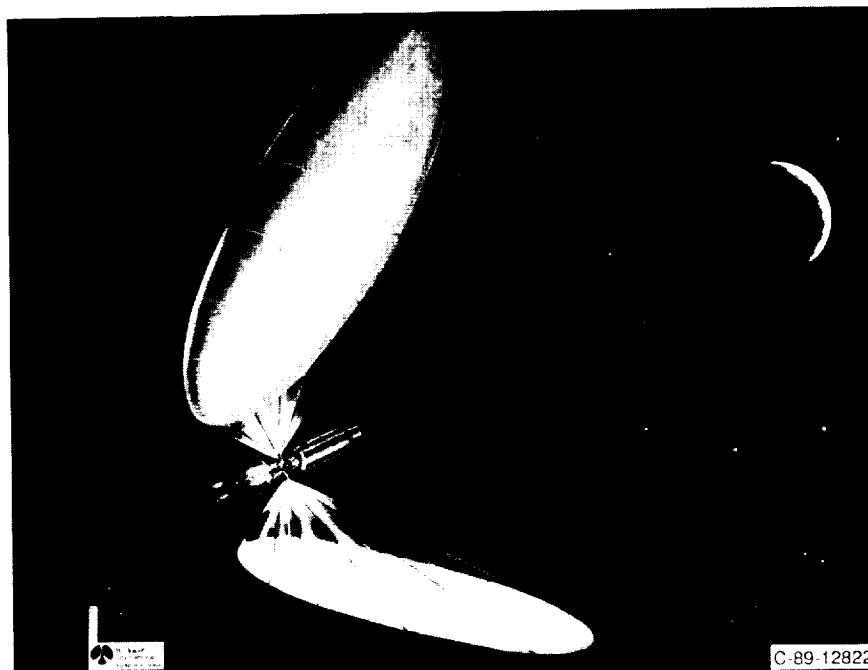
HIRS TECHNICAL REQUIREMENTS

1. OPERATIONAL RADIATOR DIMENSIONS
 - o Dia - 8'
 - o Height - 40'
 - o Area input opening to radiator is 1/4 total radiator cross sectional area
 - o Time expanded in polar orbit is 100 minutes
 - o Operational time 4 min
 - o Continuous operations 2 min
2. FABRIC REQUIREMENTS
 - o Water permeability - as low as possible
 - o Tensile strength - 500 lbs/linear inch
 - o Temperature - 75°C
 - o G Force - max of .1G in space
 - o Launch forces will be same as the space shuttle
 - o Withstand radiation intensity from the sun as a 6000K Black Body at 1350 W/M^2
 - o Minimum contamination leakage
 - o Internal pressure - Max 5.6 psi
 - o Compatible with water vapor and liquid for long periods of time (10 yr.)
3. RADIATOR must be capable of expanding and contracting in space a minimum of 25 times.
 - o Test once a year for 10 years
 - o Potential use as a weapon is 15 times
4. SYSTEM WASTE HEAT REQUIREMENTS
 - o Operation - 10 to 100 MW
5. TRANSPORTATION - Must be collapsable as cargo to fit into the space shuttle.
6. WATER RESERVOIR/BAG - 10KG
7. HEAT RATE DISSIPATION TO SPACE 3.8 KILOWATTS

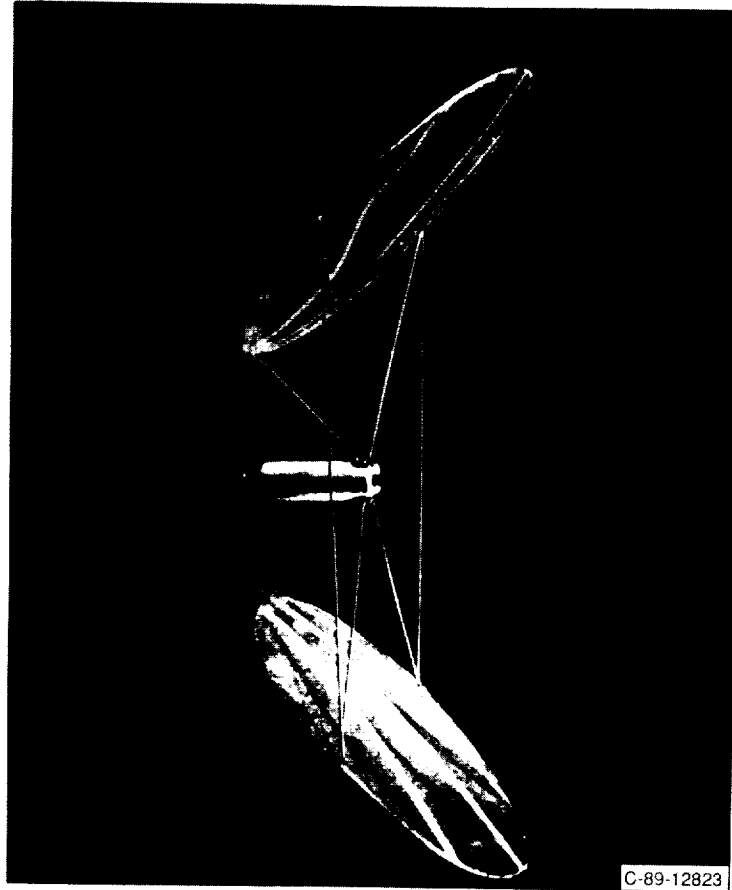
INFLATABLE SPACE TARGET



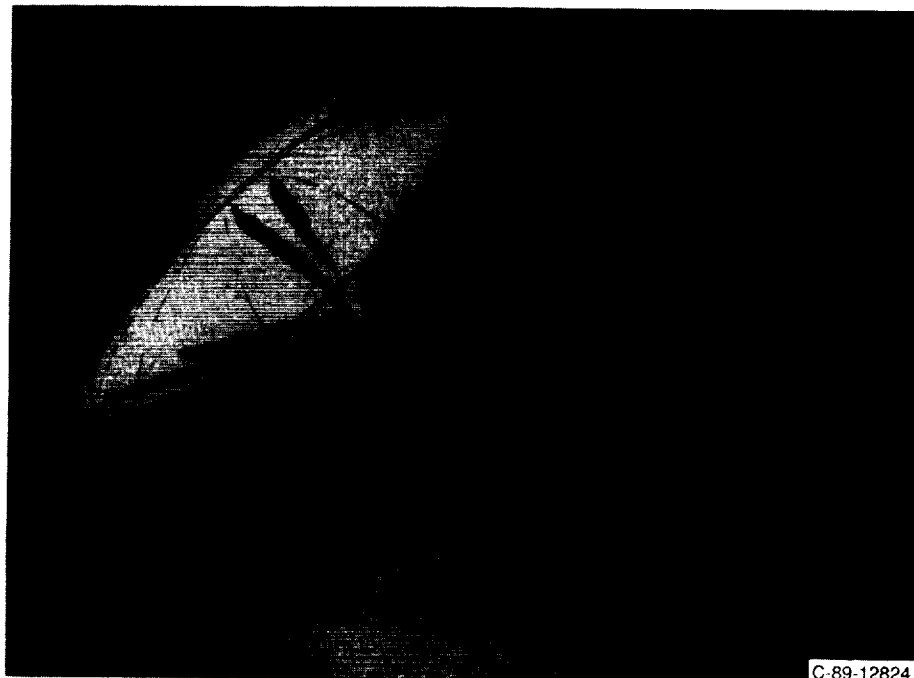
SOLAR THERMAL ROCKET



SOLAR THERMAL ROCKET - L'GARDE DESIGN



INFLATED REFLECTOR CONCEPT



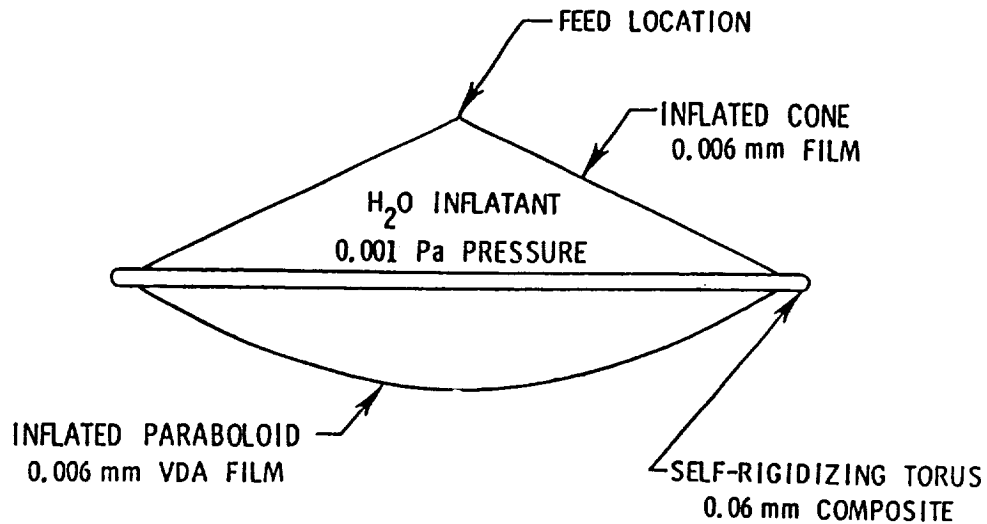
NASA INFLATED THIN-FILM SATELLITES

SYSTEM	WT (LB)	DIA (FT)	LAUNCH DATE	LIFE (YEARS)	PURPOSE	FILM/METAL THICKNESS (MIL)
ECHO I	135	100	AUG 1960	5	COMM.	0.5 FILM/VDA
EXPLORER IX	34	12	FEB 1961	3	HI-ALT. DENSITY	.5 FILM (2) .5 AL (2)
EXPLORER XIX	34	12	DEC 1963	2	HI-ALT. DENSITY	.5 FILM (2) .5 AL (2)
ECHO II	580	135	JAN 1964	-	COMM.	.35 FILM .18 AL (2)
PAGEOS I	149	100	JUNE 1966	5	EARTH SURVEY	.5 FILM VDA (2000 Å)

ADVANTAGES OF INFLATABLE REFLECTOR

- CONFIGURATION
 - SUPPORTED AT POWER UNIT
 - RADIATOR CLOSE TO POWER UNIT
- DYNAMICS
 - MASS CONCENTRATED AT GIMBAL
 - GOOD DAMPING OF MOTION
 - GENERALLY NOT SIMPLE HARMONIC MOTION
- RELIABILITY
 - TOTAL INFLATABLE PACKAGE EASILY REPLACED
 - INFLATABLES HAVE SPACE EXPERIENCE
 - GROUND TESTABLE
- PRACTICALITY
 - LOW WEIGHT AND VOLUME
 - LOW ENGINEERING/MANUFACTURING COST
 - DEVELOPMENT ALREADY STARTED
 - EVA MINIMIZED
- PERFORMANCE
 - INCREASING INTERCEPT AREA IS MINOR CHANGE
 - TUNING POSSIBLE THRU PRESSURE ADJUSTMT.

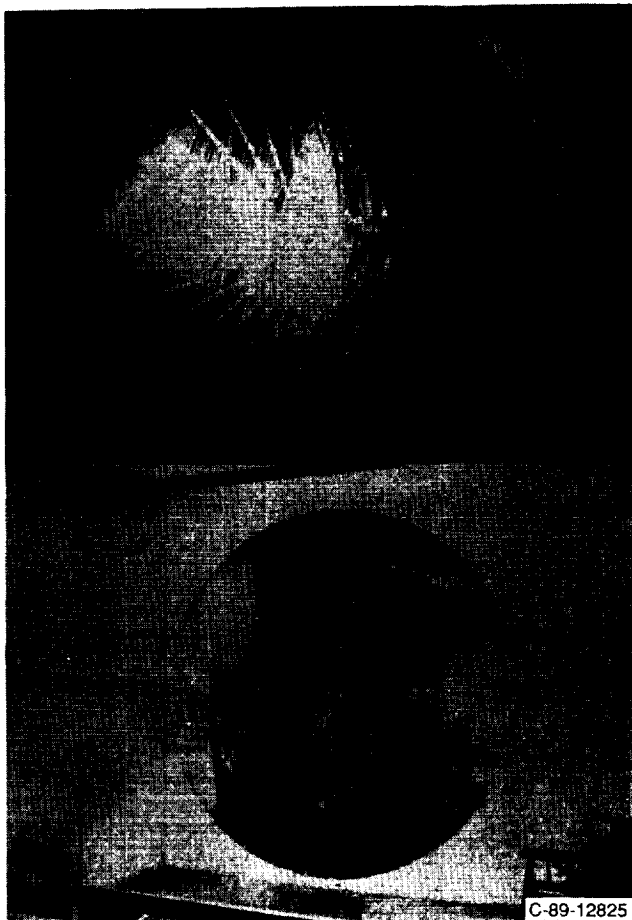
ANTENNA CONFIGURATION



NEAR TERM APPLICATIONS FOR LARGE INFLATABLE ANTENNAS

<u>AGENCY</u>	<u>SYSTEM</u>	<u>COMMENTS</u>
U. S. STATE DEPARTMENT	VOICE OF AMERICA	700 FT. DIA., 26 MHZ
NASA	GROUND MOBILE	200 FT. DIA., 850 MHZ
U. S. NAVY	INTEGRATED TACTICAL SURVEILLANCE SYSTEM	SYNCHRONOUS VERSION, 200 FT. DIA.
U. S. AIR FORCE	SPACE RADAR MM-WAVE RADIOMETER SOLAR CONCENTRATOR "DARK" PROGRAMS	PHASED ARRAYS PRIME CANDIDATE 10-30M, BETTER ACCURACY NEEDED SOLAR ROCKET 50-250 FT. DIA.

3 - METER INFLATED REFLECTOR - UNINFLATED
CONDITION, DEVELOPED FOR NASA LANGLEY

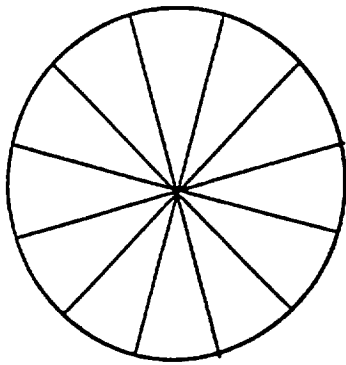


3 - METER INFLATED REFLECTOR -
INFLATED CONDITION

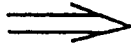


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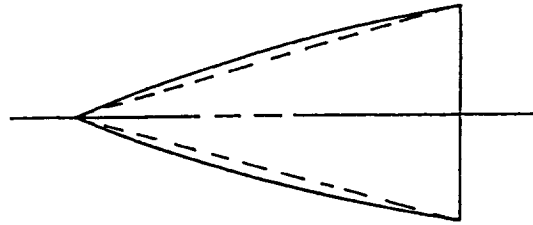
GORE DESIGN



ON-AXIS REFLECTOR



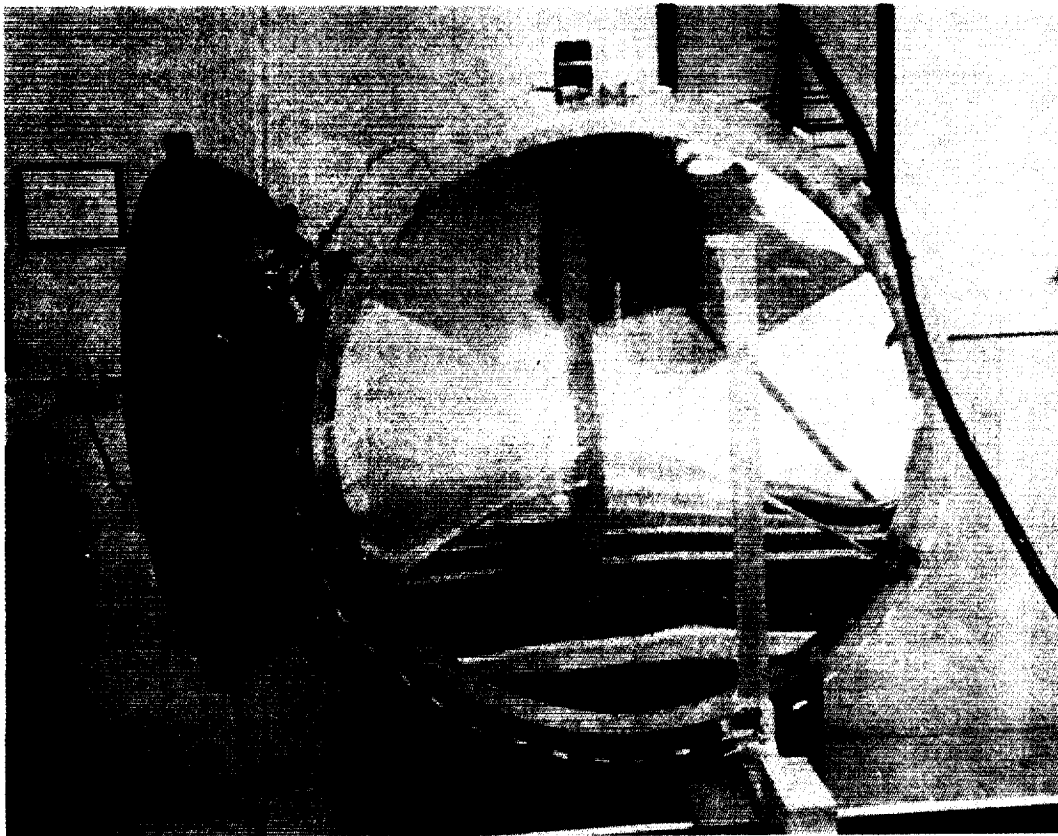
DETERMINE SHAPES OF THE GORES THAT WILL
FORM A PARABOLIC DISH UPON INFLATION



"FATTER" THAN A TRIANGULAR WEDGE

** USE FLATE CODE **

ONE M ONE METER DIAMETER INFLATED REFLECTOR DEVELOPED FOR THE^B
AF ROCKET PROPULSION LAB

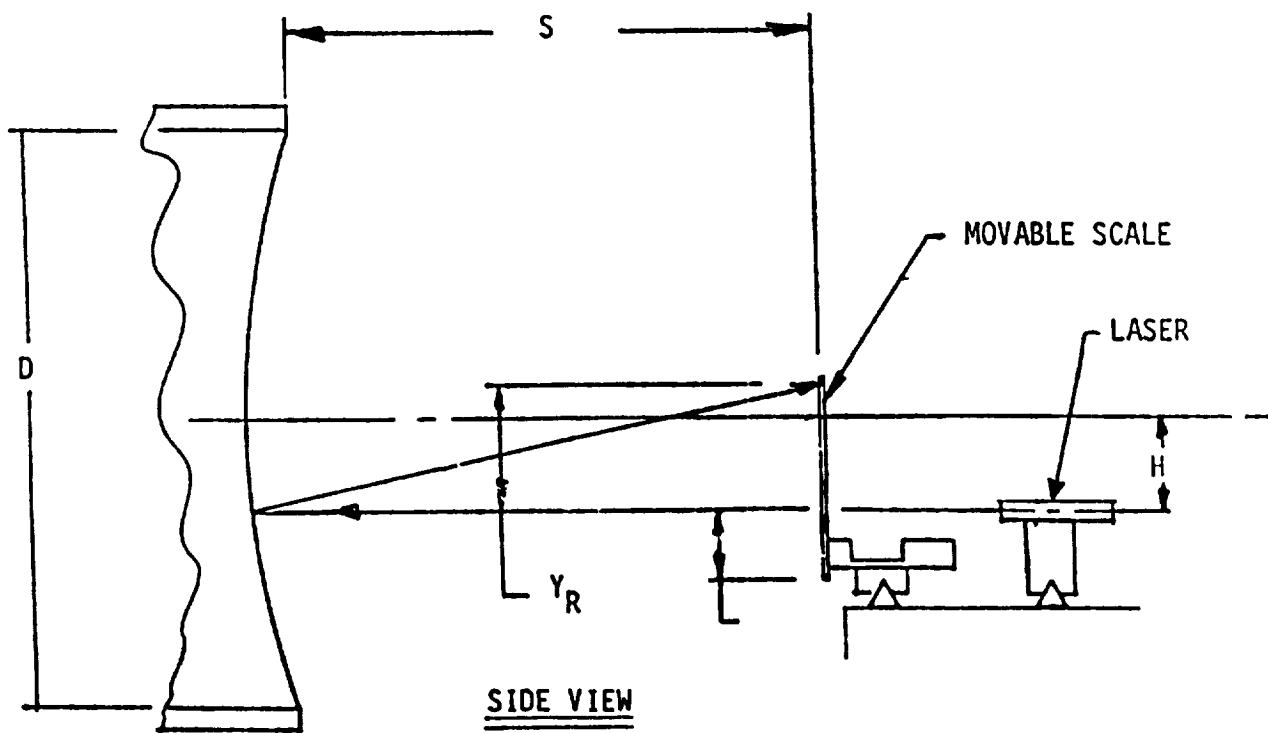
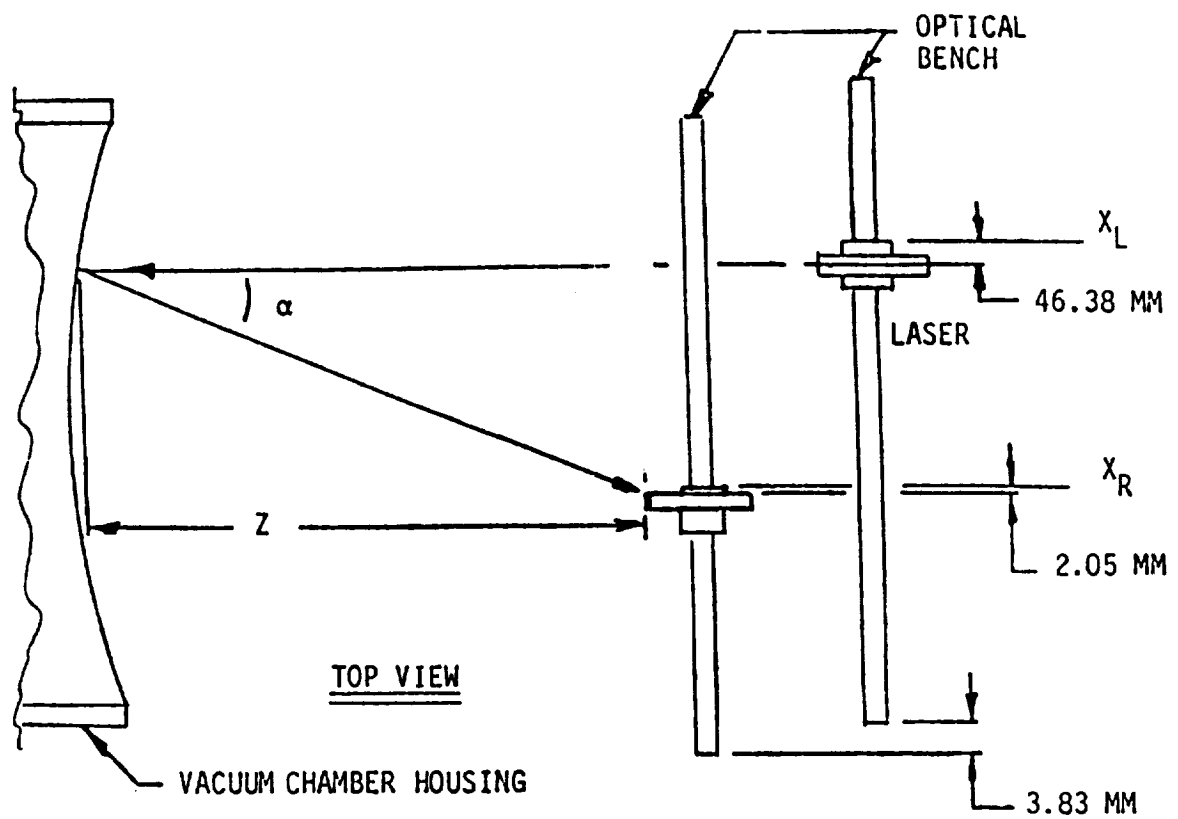


3-Meter-Diameter Test Paraboloid
(HAIR Program)



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BLACK AND WHITE PHOTOGRAPH

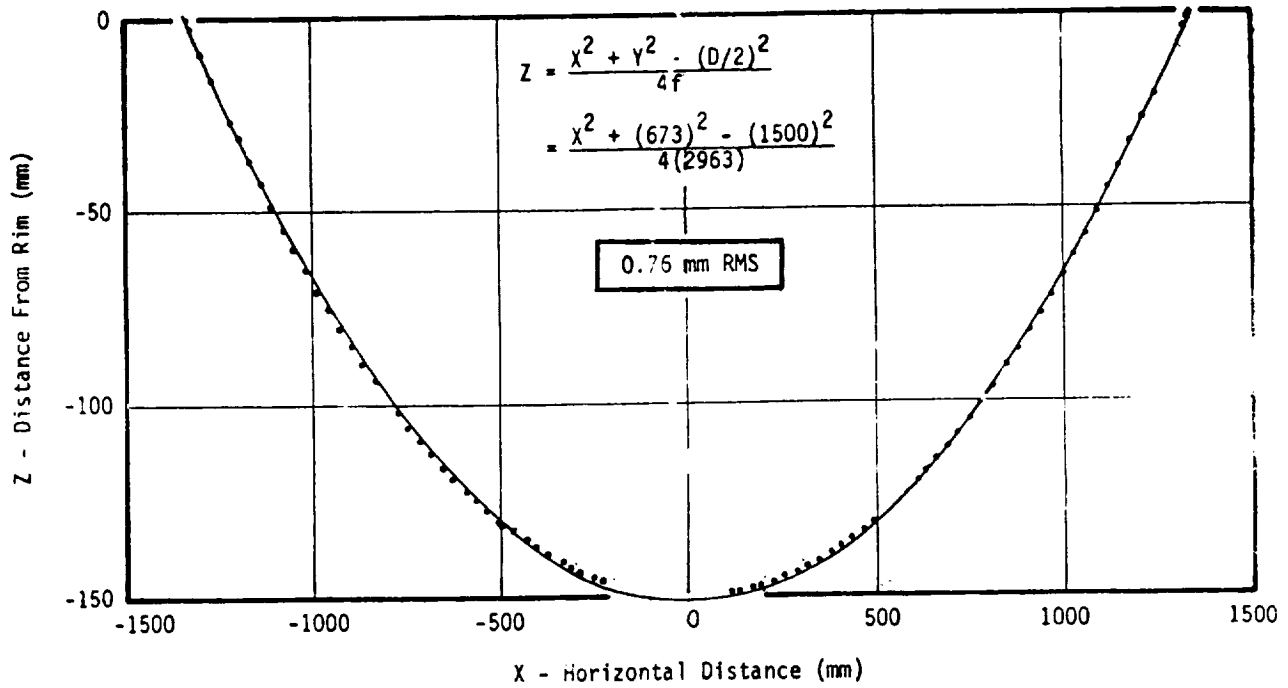


SLOPE-MEASUREMENT OPTICAL SETUP

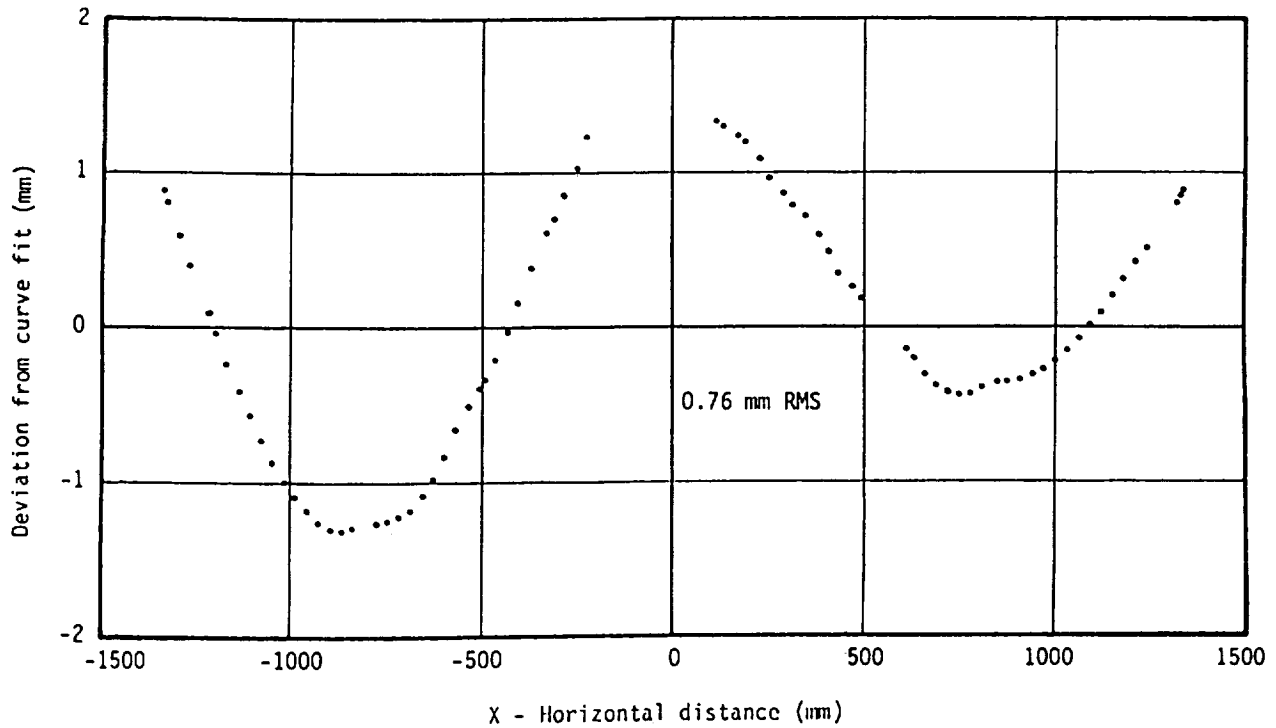
MEASUREMENT OF PARABOLOID SURFACE ACCURACY

32 1/2-mil VDA Mylar Gores
1/2-mil Mylar Tape

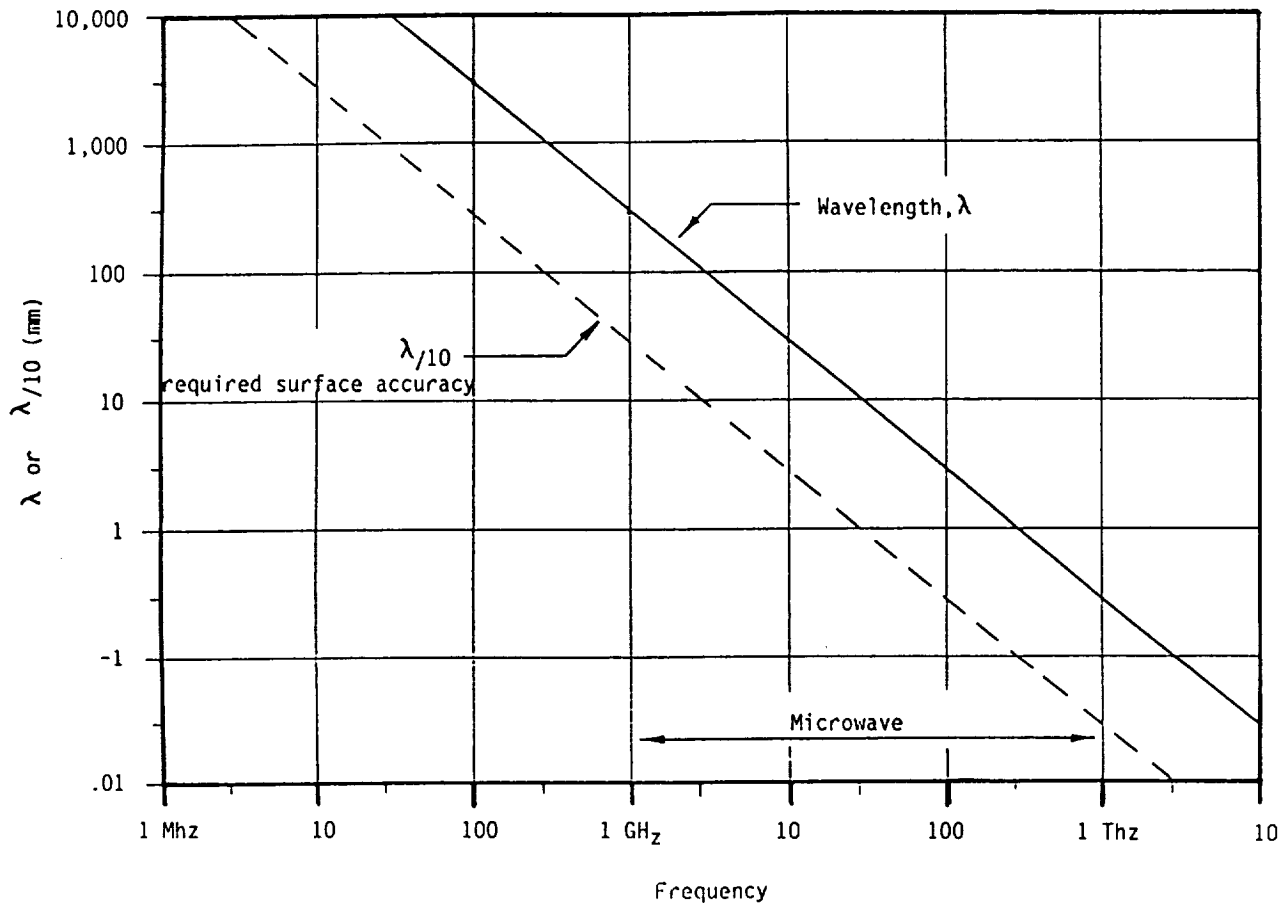
3 Meter Diameter
Measured 673 mm Below Centerline



MEASUREMENT OF PARABOLOID



REQUIRED ANTENNA ACCURACY



CYLINDER TESTS

THESE RIGIDIZED CYLINDERS WILL FORM THE TORUS OF THE INFLATED ANTENNA.

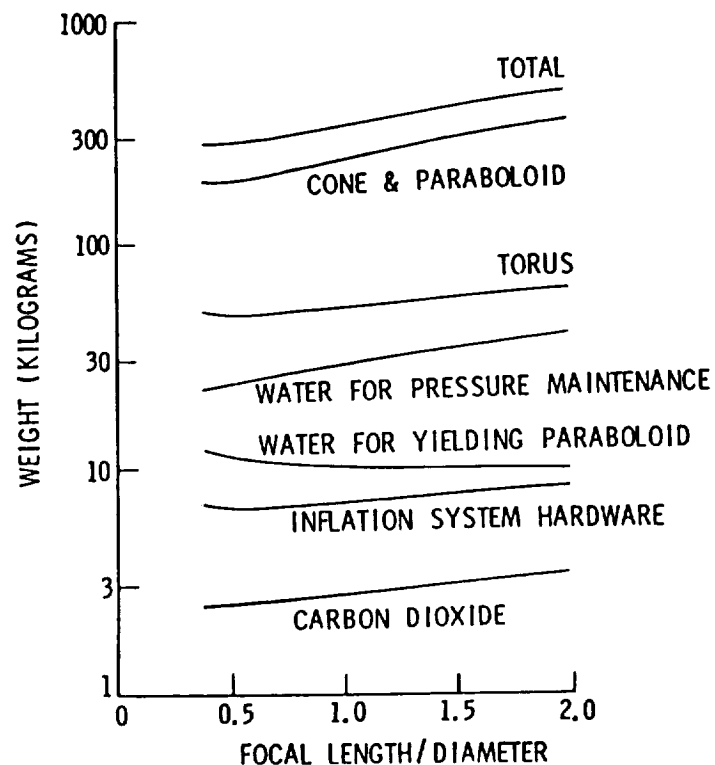


BEFORE PRESSURE

AFTER PSIG

AFTER 49.5 LBS FORCE COMPRESSIVE

WEIGHT BREAKDOWN FOR 100-METER DIAMETER REFLECTOR



PROGRAM PLAN

1. 1.0 mm accuracy
 - have demonstrated this for NASA and AFAL
 - need to incorporate torus
 - 1.5 years to build 10 meter flight reflector
 - roughly \$2 to \$3 million

2. 0.1 mm accuracy
 - best tests have yielded 0.1 mm
 - need higher pressures, heavier torus
 - 3 meter testing
 - three years to build 10 meter flight reflector
 - roughly \$5 million

